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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

OAST SPACE THEME WORKSHOP

VOLUME III

(NASA-TM-80011) OAST SPACE THEME WORKSHOP.

N79-15123

VOLUME 3: WORKING GROUP SUMMARY. 4:

SOFTWARE (E-4). A. SUMMARY. B. TECHNOLOGY

NEEDS (FORM 1). C. PRIORITY ASSESSMENT

Unclas

(FORM 2) (NASA) 50 p HC A03/MF A01 CSCL 22A G3/12

42664

WORKING GROUP SUMMARY

IV. SOFTWARE (E-4)

A. SUMMARY

B. TECHNOLOGY NEEDS (FORM I)

C. PRIORITY ASSESSMENT (FORM II)

HELD AT THE
LANGLEY RESEARCH CENTER
APRIL 26-30, 1976



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Foreword

The attached material represents the working papers from the OAST Space Theme Workshop held at the Langley Research Center, April 26-30, 1976, and contains a quick-look analysis of the proceedings. The material is unedited and intended for further use by the participants of the workshop and the planning elements of NASA concerned with space mission research and technology. It should be understood that the data do not represent official plans or positions but are part of the process of evolving such plans and positions.

Nearly 100 of the Agency's top technologists and scientists joined with another 35 theme specialists to produce this working document - a document that provides a technical foundation, including research and technology base candidates, for each of the six space themes.

The material in this report is considered essential to the development of Center initiatives in support of these themes. Copies of the report will be made available to the Center Management Board and the individuals at the Centers responsible for the FY'78 program planning cycle. The timing of this planning activity has caused us to distribute this document in this unedited form. Thus, it possibly contains errors, hopefully, more of a typographical rather than a technological nature. Nonetheless, the information contained is of a high professional level, reflecting the efforts of the workshop participants and will be invaluable to the planning and successful execution of the Agency's near- and far-term advanced technology program.

Stanley R. Sadin
OAST Space Theme Workshop
Chairman
NASA Headquarters
Study, Analysis, & Planning Office
Office of Aeronautics and
Space Technology

VOLUME III - IV A

SOFTWARE WORKING GROUP (E-4)

Initiation of a specific technology planning effort for software (computer programs) occurred at the workshop; that is the subject of this report. In the process of examining the technology needs of the themes and the software discipline, three key areas have been identified:

1. The need to develop an adequate software technology base: There are only a few efforts currently underway, and many are needed. Particular areas where concentration is needed include
 - o Software commonality and evolutionary capability
 - o Increased system integrity and autonomy
 - o Improved communications among the program users, the program developers, and the programs themselves.
2. The need for a quantum improvement in software development methods. Emphasis is needed on
 - o Replacing magic with method
 - o Using people for ideas, and machines to perform routine work.
3. The need for increasing the awareness of software by all concerned.
 - o Software should receive equal consideration with hardware in an increasingly system-oriented approach
 - o Software presents many opportunities for enlightened management.

Five major thrusts have been identified within the software area - Contributions to major goals are shown in Figures 1 and 2. These are

1. Data and Systems Management. Improvements in this area also will contribute to raising the quality of service received by the ultimate user of the processed information.
2. Software technology for autonomous systems.
3. The technology and methods for improving the software development process.
4. Advances related to systems of software elements including their architecture, attributes as systems, and interfaces with users and with other systems.

5. Applications of software, including both the basic algorithms used in a number of applications and the software specific to a particular theme or discipline area.

Specific technology initiatives are addressed in the Appendix.

A number of additional observations have emerged from the working group's considerations, some of which are included below.

- o Increased awareness of software, and of the need to treat it as a key element of each system using it, is of critical importance. The technical areas using software, and management in general, are in particular need of such increased awareness.
- o The identification, direction, and accomplishment of an effective software technology program is of great importance to all major NASA programs.
- o A sharp and continued increase in effective communications and exchange of ideas within the NASA software community, and with hardware activities that interact with software, should be achieved (The software working group transactions demonstrated both the need for, and the value of, such interaction.)
- o Software is an integral, critical part of each theme, and of many disciplines. Each of these areas needs to consider the hardware and software aspects of its work concurrently, from a system oriented viewpoint. Each of these areas also needs to develop the software specific to its particular needs, to ensure that its system requirements are met.
- o A vigorous software discipline oriented activity should exist to complement the work in themes and disciplines by developing generic types of software capabilities and software development methods. These products form the technical resources that the themes and disciplines can draw from for their particular development.
- o The net result of the above two ideas is that the software discipline area should concentrate on the basic methods and generic types of software capabilities, while the themes and other discipline areas should develop applications software specific to their needs.
- o Another important task of the software discipline area is to make the basic software capabilities and methods easily available to the mainstream of software development activity. A backlog of currently available items already exists in this category.

- o An important area of concern for the software discipline area is the development of effective methods for assessing the impact of new technology and capabilities on software development and use. Measurements of cost and of utility to the ultimate user are of particular importance, both to selective technology for use, and to directing further technology development.
- o Computational hardware has a significant impact upon the accompanying software in each information-processing application. The mainstream of computational hardware development, including particularly integrated-circuit components, appears to be driven by the non-government, mass-volume users. This will result in the availability of low-cost, highly reliable components. However, these components may have characteristics that seriously constrain software in space systems. NASA will need to exercise foresight, ingenuity and effort to minimize the effect of this situation upon space systems.

The available hardware should be exploited to the fullest extent practicable. A vigorous program of computing device technology should complement NASA's software technology. This will help to promote the concept of software - first information processing design, and to ensure that hardware with the necessary characteristics is available.

The directions in which expected hardware trends will drive the software technology should be assessed, to provide a basis for identifying opportunities or needs for contributing to or influencing hardware developments.

Software Technology Related to Theme Needs

The following paragraphs address each theme need and the important software technology areas which it impacts.

1. Multipurpose Space Power Platform

The major impact of space power on software will be in the areas of

- a) Mission planning and scheduling to incorporate effective use to the platform and its generated power for the use of its customers (analogous to the earth power distribution systems)
- b) Implementation and access of the large data base necessary to support effective mission planning noted above
- c) Development of teleoperators and robots including their multiple utilization to support construction and maintenance of the facility

- d) Development to maintain system integrity (failure detection, fault isolation, preventive maintenance, etc.) and system security while maintaining efficient operation.

2. Space Industrialization

The Space Industrialization Theme will require initiatives in the areas of Planning and Scheduling Tools and Multi-dimensional Data Management, for plant control and management; Teleoperator Support Software and Autonomous Systems with Artificial Intelligence, for factory construction, materials processing and product fabrication. Other need areas which provide important support for this theme are Software for Systems Integrity and Operations Languages, to assure reliable, effective, and economical plant operation.

3. Search for Extraterrestrial Intelligence (SET I)

The major impacts of SET I on software are:

- a) new technology on adaptive, human-assisted pattern recognition to enable the effective separation review information.
- b) the requirements for new technology in data management areas of multi-dimensional data storage and high speed buffering
- c) need for evolutionary software technology where new computational tasks will be required over a long life-cycle without major system perturbations.

In addition, the working group felt that the SET I theme needs to examine more thoroughly its software requirements, begin to assess the impact of software on the overall program and to identify the theme-oriented software needs and areas in which software technology can make an important impact.

4. Exploration of Solar System/Software Technology

The three key software technology thrusts identified as essential for the exploration of solar systems theme are those software tool and technique developments related to: (1) achieving increased levels of autonomous operation of the flight systems; (2) improving the methods for verification and validation of complex software systems; and (3) reducing the dependence on intensive human participation in uplink command and control of long duration missions. These software developments are expected to result in reducing both the development and operations costs of solar exploration missions as well as permitting the actual accomplishment of the missions planned.

For autonomous systems the software tools and architecture developments will provide the capabilities for developing applications software that can synthesize plans, perform decision analysis and alternate strategy selection, interpret and analyze sensor data, and provide fault-tolerant operation of the complete system. Prototype development and a demonstration is planned by FY 82 with continued improvements in capabilities development which are expected to meet the technology cut-off date for the exploration facility.

The automated software verification and validation tools are essential to increasing the confidence level in the reliability of large-scale software systems without requiring unrealistic resources to achieve acceptable confidence levels. By the end of FY 81 these tools should be sufficiently developed to permit application to mission software systems, both ground and flight.

The software tools for mission planning and scheduling functions for uplink command and control will include development of problem oriented languages which will provide a highly adaptive and interactive capability. Operational tools should be available by FY 81.

5. Global Service Systems

The Global Service Systems theme has broad software technology needs; alone among the themes, its needs touch each of the 19 identified task areas. The principal thrusts include needs for multi-dimensional Data Storage and Retrieval Techniques to handle the massive amounts of data which this theme would generate; Operations Languages, for user-oriented interfaces for systems control; Software for Systems Integrity, to assure reliable systems operation in the face of hardware faults, data errors and control by inexperienced users; Pattern Recognition and Algorithm Development, to extract information from data, eventually at the source; Intelligent Executive Programs, which would be able to generate detailed goals to achieve mission objectives. Global Service Systems should develop new initiatives in each of the above areas.

6. Advanced STS

The Advanced Space Transportation System Theme has basic technology need areas in Mission Planning and Scheduling Tools and Operations Languages, to attack operations (recurring) costs; Software for Systems Integrity and Intelligent Executive Programs, to increase systems autonomy; and improved simulation for advanced systems integration and checkout concepts. This theme should generate its own theme-unique initiatives in these areas.

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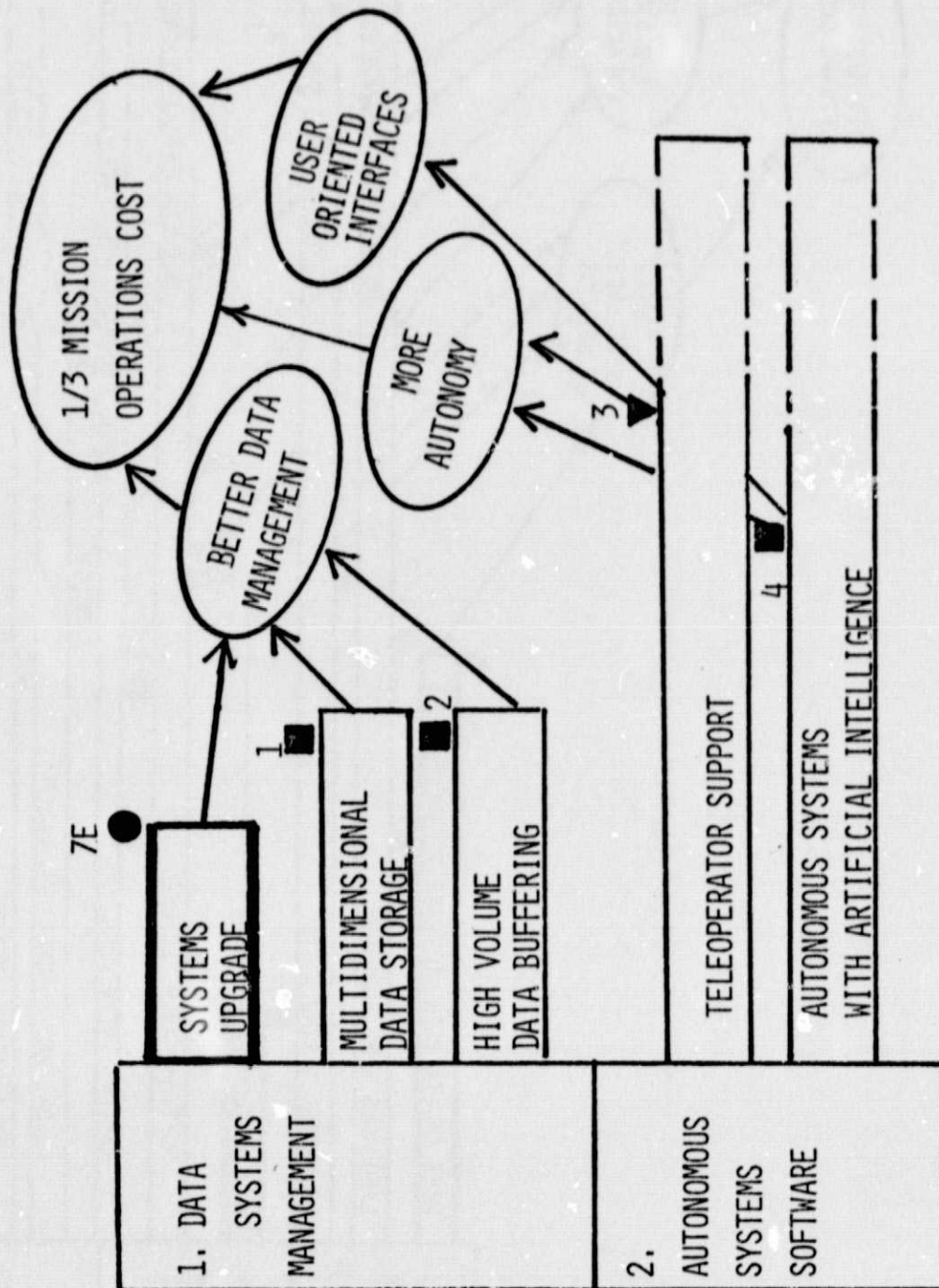
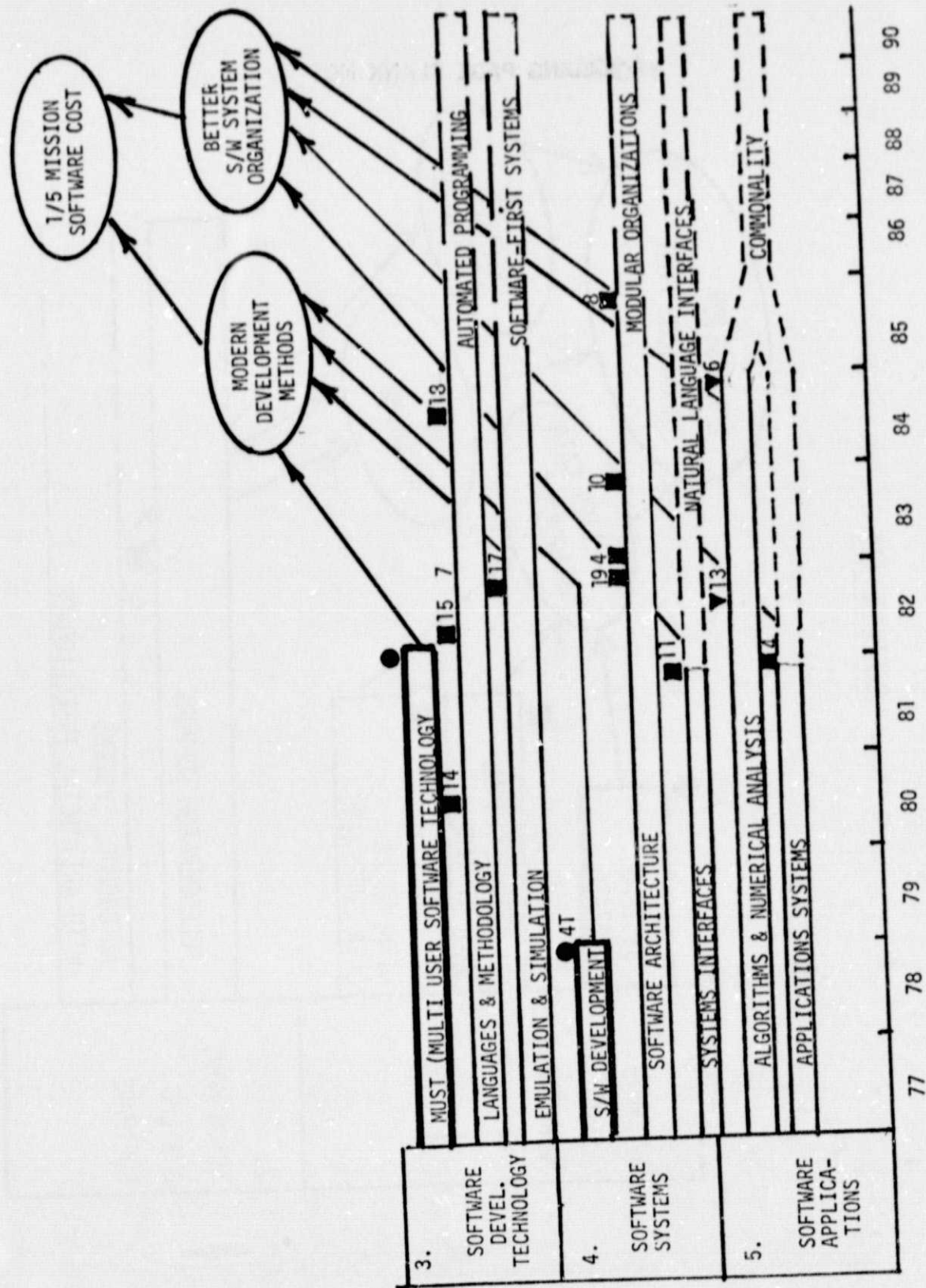


Figure 1

Figure 2
SOFTWARE (2)



5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Multidimensional Data Storage and Retrieval Techniques NO. 7,8,11,10,9,1/E-4/1
T I E M E / W . G . / T A S K

DATE 4 / 28 / 76

2. OBJECTIVE

To provide efficient means of storing and retrieving high volumes of data and maintaining file security for multidimensional data.

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 4 , WILL BE LEVEL ☒ 4 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1980
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☐ LOW ☒
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐
- e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☐ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☐ (Check one or more)
- f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY High speed random access mass storage devices.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Adaptive data base organization/management techniques to accommodate multidimensional data representation.

Methodologies to insure data file integrity and security within a multi-purpose, high volume data, multi-user environment.

Develop techniques for organizing/managing distributed/multimode data at both logical and physical level.

TITLE Multi-dimensional Data Storage and Retrieval
Techniques

NO. 7-8-11-10-9-1/E-4/1
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Determine characteristics of data representations of multi-dimensional objects/scenes

Design data base organizations to accommodate multi-dimensional data files

Exercise these files utilizing storage and retrieval techniques

7. ALTERNATIVE APPROACHES/OPTIONS**8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)****9. TECHNOLOGY SCHEDULES**

FY

SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Data characteristics																				
File structures																				
Storage/retrieval																				
Demonstration																				

MANPOWER (M-Y)
INHOUSE
CONTRACT

FUNDING (10⁶ \$)
INHOUSE
CONTRACT

1 1 1 1 - -
5 5 5 5 - -

.3 .3 .3 .3 - -

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED

2. THEORY FORMULATED TO DESCRIBE PHENOMENA

3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL

4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY

6. MODEL TESTED IN AIRCRAFT ENVIRONMENT

7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE High Volume Data Buffering Techniques

NO. 9,11,10,1/E-4/2

THEME / W.G. / TASK

DATE 4 28 76

2. OBJECTIVE

to provide software procedures for acceptance/processing of high volume data utilizing buffering techniques

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY

AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY DATE: 1982

c) RISK IN ACHIEVING ADVANCEMENT:

HIGH ☐ MEDIUM ☒ LOW ☐

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR

ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐

e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒

GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐

OTHER (Specify) ☐ (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR

USE OF THIS TECHNOLOGY High speed random access mass storage devices, multiprocessor architecture.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Develop software techniques for data acceptance utilizing advanced buffering techniques.

Determine methods of high volume data manipulation to accomplish high speed data processing requirements.

Hierarchical storage systems.

Virtual storage management.

TITLE High Volume Data Buffering TechniquesNO. 4-10-11-1/E-4/2
THEME / W.G. / TASKDATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Research current software techniques utilized for data bufferingDetermine specific needs or requirements for improved software data buffering techniquesDevelop methods/techniques to accomplish buffering of high volume data rates

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

FY

SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Research			---	---	---	---														
Tech. Inventory			—																	
Defn of Potential			—																	
Applications																				
Reqmts Generation			—																	
Dev. Meth & Tech				—																
Test & Demo					—															
Documentation					—															

MANPOWER (M-Y)																				
INHOUSE			2	2	2	1														
CONTRACT			3	4	4	3														
FUNDING (10 ⁶ \$)																				
INHOUSE			.03	.05	.12	.02														
CONTRACT			.17	.25	.28	.23														

Total \$ → .2 .3 .4 .25 Runout ≈ 1.2 M

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Teleoperator support S/W Technology for
Materials Handling and Large Construction

NO. 7,8,11,12/E-4/3
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE Develop S/W technology which will provide the efficient (time, cost, implementation, operation) use of teleoperator systems in the construction of space structures (power station, manned stations, etc.) and and operation of hazardous processor facilities.

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 2, WILL BE LEVEL ☒ 4 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☒ 7 FOR OPERATIONAL SYSTEM USE BY DATE: 1986
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☒ LOW ☐
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐
- e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☒
OTHER (Specify) ☐ (Check one or more)
- f) R&T BASE CANDIDATE No

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY Development of new teleoperator hardware systems and sensors (digital) to allow required mobility and flexibility in space.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

The software technology areas required are:

1. Interface technology - man/computer/machine or system.
2. New V/HOL or HOL languages designed for effective implementation (minimize computer size, weight, response time requirements); and to maximize flexibility of system.
3. Generalize S/W control program for multiple, coordinated, simultaneous teleoperators.

TITLE Teleoperator Support S/W Technology for
Materials Handling and Large Construction

NO. 7, 8, 11, 12/E-4/3
THEME / W.G. / TASK

DATE 4 / 28/ 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Survey and study existing technology. Define new concepts required and provide basic supporting research needed to support concepts. Develop tools and processes and implement the concept. Test breadboard version both in the ground environment and space environment

7. ALTERNATIVE APPROACHES/OPTIONS

ALTERNATIVE APPROACHES/OPTIONS Provide analog type systems to
fulfill the objectives in Part 2.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

These are current activities that include basic ground operations which are hazardous, but nothing is planned in the area of major space construction

9. TECHNOLOGY SCHEDULES

FY

[illegible][illegible]

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

LEVEL OF STATE OF ART

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF

2

1. TITLE Mission Planning and Scheduling Tools and Techniques

NO. 12-7-8-10-11/E-4/4
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

To develop concepts for Mission Planning and Scheduling techniques and S/W tools compatible with the rapid/complex requirements of advanced space missions.

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 2, WILL BE LEVEL ☒ 3 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1981
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☒ LOW ☐
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐
- e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☐ (Check one or more)
- f) R&T BASE CANDIDATE Probably not

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Advanced algorithm implementation (faster solutions) and improved interactive techniques.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Develop the S/W tools capable of planning and scheduling the resources and operations associated with advanced space missions. Also development and apply in problem oriented languages for programming (modifying) the S/W system, develop and apply interactive techniques related to operating the system. More specifically, as one part of the task, develop a flexible S/W system to be used in the man vs machine trade-off studies for performing mission planning functions.

TITLE Mission Planning and Scheduling Tools and
Techniques

NO 12-7-8-10-11/E-4/4
 THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Determine inventory mission planning and scheduling requirements for Advanced STS. Develop generic requirements for an initial S/W tool (bench program) and use tool to assist in defining technique and tool needs for operations of Advanced STS. Perform similar tasks for other types of mission planning and scheduling software applications

7. ALTERNATIVE APPROACHES/OPTIONS (a) Much larger mission planning and scheduling force (5-10 time larger than now), (b) Much lower flight rate.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

In-house effort related to a Shuttle STS tool (which will probably not be at the technological level required for Adv STS).

9. TECHNOLOGY SCHEDULES

FY

SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Opr. Concepts			-																	
Generic Regmts				-																
System Concepts				-																
Bench Prog.					-															
Tech/Analysis					-															
Recom. for Ops					-															
Tools & Tech																				

Δ Begin Ops Tools & Techniques

MANPOWER (M-Y)																				
INHOUSE			2	2	2															
CONTRACT			3	4	3															
FUNDING (10 ⁶ \$)																				
INHOUSE			.03	.05	.05															
CONTRACT			.17	.25	.20															

.2 .3 .25 Runout ~ .75 M

SPACE TECHNOLOGY NEED

FORM NO. I

PAGE 1 OF 2

1. TITLE Autonomous Systems with
Artificial Intelligence

NO. 10-7-8-9-12-11-1/E-4/5
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

To develop the software architecture required for the implementation
of autonomous systems (e.g. robotics).

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 2, WILL BE LEVEL ☒ 3 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1990
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☒ MEDIUM ☐ LOW ☐
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR
ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐
- e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☒ Computer simulation (Check one or more)
- f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY

Development of large (~10⁷ word) associative
memories and large scale array processing.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
ACCOMPLISH NEED

Develop software techniques and architecture capable of providing:

- Natural language understanding
- Plan synthesis
- Decision analysis and alternate strategy selection
- Interpretation and analysis of data from imaging, tactile, thermal,
etc. sensors
- Fault-tolerant system operation

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT
ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL
OF STATE
OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR
MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

TITLE Autonomous Systems with Artificial Intelligence NO. 10-7-8-9-12-11-1/E-4/5
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Select available natural language and basic algorithms for evaluation and criteria definition. Develop and progressively improve language. Develop initially basic algorithm and progressively improve. Develop increasingly more complex algorithms and integrate into complete system capability

7. ALTERNATIVE APPROACHES/OPTIONS

None defined.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Robotics Research Program RTOP #

Artificial Retina (New Initiative). Pattern Recognition (New Initiative & W. G. E4 Task 6)

9. TECHNOLOGY SCHEDULES

FY

SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Analyze Lang.			■	■																
Criteria for Lang.				▽																
Algorithm & Lang.			■	■	■	■	■	■	■	■	■	▶								
Proto Demo						▽														
Incr. Capabilities							■	■	■	■	■	▶								

MANPOWER (M-Y)
 INHOUSE
 CONTRACT

			4	8	8	9	9	4	.	.	.	▶								

FUNDING (10⁶ \$)
 INHOUSE
 CONTRACT

			.3	.6	.6	.8	.8	.3	.3	.	.	.	▶							

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE S/W Languages and Technology for Pattern
Recognition

NO. 9-11-10-1/E-4/6
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

Develop theory and implementations for semantic perception and inter-
pretation of patterns and objects in multi-dimensional dimensional
feature space

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 1, WILL BE LEVEL ☒ 2 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1984
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☒ MEDIUM ☐ LOW ☐
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR
ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐
- e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☒ SPACE FLIGHT TEST ☐
OTHER (Specify) ☐ (Check one or more)
- f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY Imaging sensors and systems, parallel/associa-
tive processors, holographic/optical transform.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
ACCOMPLISH NEED

Languages and data structures

Semantic models of scenes

Adaptive learning algorithms

Pattern classifiers

Picture grammars

Edge, shape and texture recognizers

Associative processing

5. COMPONENT OR READBOARD TESTED IN RELEVANT
ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL
OF STATE
OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR
MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Automated Programming

N/O. 12-11-10-1/E-4/7
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

Provide problem-statement languages and processors for direct trans-
formation from problem statements to programs.

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 2, WILL BE LEVEL ☒ 2 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE:
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☒ MEDIUM ☐ LOW ☐
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR ENHANCING: HIGH ☐ MEDIUM ☒ LOW ☐
- e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☐ (Check one or more)
- f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

Artificial intelligence, data and control
abstractions

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Semantic understanding models

Problem-oriented languages

Design and development of translator(s)

Ambiguity and redundancy

TITLE Automated Programming

NO. 12-11-10-1/E-4/7
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Develop semantic models for computation structures.

Develop problem-oriented specification languages for promising candidate classes of problems (e.g., BNF for string processing programs).

Develop heuristics and associated processors for autotranslators into implementation source languages.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

[illegible][illegible]

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE System Security Software TechnologyNO. 7-11-1/E-4/8

THEME / W.G. / T.A.

DATE 4 / 28 / 76

2. OBJECTIVE

Develop software technology which will provide the capability to secure computer controlled space systems

3. NEED ANALYSIS

a) LEVEL NOW ☒ 4, WILL BE LEVEL ☒ 4 UNDER EXISTING PLANS.b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1990

c) RISK IN ACHIEVING ADVANCEMENT:

HIGH ☐ MEDIUM ☐ LOW ☒d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐OTHER (Specify) ☐ (Check one or more)f) R & T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

Security interfacing systems and controls

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

The software technology areas required to achieve the objectives are:1. Development of software and hardware arch. To provide security and limit access to large systems operations, S/W.2. Development of a operation systems security language implement effective security codes.Adapt the principles of source operating systems to preclude the unauthorized use of space system.

5. COMPONENT OR BREAKDOWN TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

LEVEL
OF STATE
OF ART

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 3

1. TITLE Software for Systems Integrity-Safety NO. 12-11-8-10-7-9-1/E-4 9
Diagnostic Reliability, Fault Tolerance and THEME / W.G. / TASK
Redundancy DATE 4 / 28 / 76

2. OBJECTIVE

Technology to format program and test software architecture and procedure
to maintain system integrity in the face of failure or data error.

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 3, WILL BE LEVEL ☒ 4 UNDER EXISTING PLANS.
b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE:
c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☒ LOW ☐
d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR
ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐
e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☐ AIR CRAFT TEST ☒ SPACE FLIGHT TEST ☒
OTHER (Specify) (Check one or more)
f) R&T BASE CANDIDATE YES

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR
USE OF THIS TECHNOLOGY Smart sensors (parts), distributed computer
implementation theory and practice.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

(a) Develop system architecture, format and program concepts (language
procedural software) to incorporate the fault tolerance and redundancy
inherent in the spacecraft design into fault isolation and detection
procedures. (b) Develop failure decision and adaptive learning theory
and program implementation to establish or set onboard failure levels
consistent with information environment and system status, (c) Develop
executive logic technology to perform intelligent selection of spacecraft
operation and mission selection based upon status and success probabili-
ties, (d) Develop procedure to effectively assess the reliability trade-
off inherent in various implementation strategies and (e) Develop
theory for the quantitative measure of software redundancy, fault and

(cont'd on page 3)

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 3

TITLE Software for System Integrity

NO. 12-11-8-10-7-9-1/E4/9
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Determine software capabilities needed to insure that total system integrity can be maintained. Implement and verify the methods/algorithms required to provide integrity capability.

Demonstrate, analyze, and appropriately modify the software capabilities.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Related activity in Shuttle and aircraft technology program.

9. TECHNOLOGY SCHEDULES

FY

[illegible][illegible]

7. TITLE Software for Systems Integrity-SafetyNO. 12-11-8-10-7-9-1/E-4/9Diagnostic Reliability, Fault Tolerance and

THEME / W.G. / TASK

RedundancyDATE 4 / 28 / 76

(5) CONTINUATION (If Needed)

Block No.

data error tolerance and their application to effective total systemintegrity principles.

5. COMPONENT OR BREAKDOWN TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

LEVEL OF STATE OF ART

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Evolutionary Software

NO. 11-9-8-7-10-12-1/E-4
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

To develop advanced concepts which will provide for evolutionary software within expanding computer Architectures

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 2, WILL BE LEVEL ☒ 4 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1983
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☒ LOW ☐
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐
- e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☐ (Check one or more)
- f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

Advanced computer Architecture

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Provide methods for design/development of advanced operating systems to perform within an expanding computer Architecture such as distributed computer systems.

Determine operating systems/applications software functions which could be implemented with growth potential as an integral characteristic.

Develop techniques for implementing/testing these features. Hardware/Software Architecture trades.

5. COMPONENT OR BOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Operations Languages

NO. 11-10-12-8-7-1/E-4 11
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

Develop languages and interpreters for effective expression and execution of systems directives and procedures.

3. NEED ANALYSIS

- a) LEVEL NOW 2, WILL BE LEVEL 4 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1981
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☒ LOW ☐
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR
ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐
- e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☐ (Check one or more)
- f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

Data and control abstractions. Human factor for man/machine interface.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Natural pseudolanguages

Semantic understanding models

Operations language implementations

Process communication and synchronization

Run-time environment models

Human factors related to languages

TITLE Operations Languages

NO. _____ /E-4/11

THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Perform research on need for operations languages, human factors considerations and pertinent language, data, control and systems theories.

Develop base languages for prototype implementations and comparative testing.

Provide guidelines and design support for dialect developments, including language evaluation activities.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

310-40-40, \$50K

9. TECHNOLOGY SCHEDULES

FY

V Initial products

[illegible][illegible]

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. I

PAGE 1 OF 2

1. TITLE Intelligent Executive Programs

NO. 12-11-9-10-1/E-4 12

THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

To design, develop and test executive programs capable of interpreting plans and guidelines and executing operational sequences and data management functions to accomplish system operational goals.

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 2, WILL BE LEVEL ☒ 4 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1983
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☒ MEDIUM ☐ LOW ☐
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR ENHANCING: HIGH ☒ MEDIUM ☒ LOW ☐
- e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☐ (Check one or more)
- f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Develop executive programs which can be externally controlled by user plans and goals. Provide for flexible execution sequences such as table driven command lists, as well as internal adaptive goal-oriented planning and execution. Provide inherent capabilities for the executive to establish execution priorities based on mission goals/system capabilities.

TITLE Intelligent Executive Programs

NO. 12-11-9-10-1/E-4/12

THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

- Identify systems requirements and research computer sciences discipline capabilities.
- Design prototype executive for candidate mission class.
- Implement and evaluate prototype executive and supply guidelines and support for flight implementations.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

[illegible][illegible]

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Algorithm/Numerical Analysis Development

NO. 11-10-12-1/E-4 13

THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

To develop theoretical computation and implementation algorithms for flight and ground S/W consistent with computer architecture requirements and constraints for advanced space missions.

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 2, WILL BE LEVEL ☒ 3 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1990
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☐ LOW ☒
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐
- e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☐ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☒ Computer Simulation (Check one or more)
- f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

Compatible H/W (flight computers) common software technology and library development

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Development of (a) linearized (or analytical) solutions for, for example, advanced differential equations associated with spacecraft-independent navigation, guidance, structural, thermal, and (b) efficient algorithm and library-quality routines for mission planning, mission support, and data analysis, and (c) the development of the implementation of algorithms which will satisfy computer architecture requirements and constraints, such as solution speed, limited memory and distributed architecture.

TITLE Algorithm/Numerical
Analysis/Development

NO11-10-12-1/E-4/13
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

- A. Accelerate advanced math computation research utilizing university and support contractor expertise. Convert to basic algorithms for various spacecraft and ground applications. Recommend H/W factors.
- B. Continuing development of efficient algorithms for general-purpose ground software.

7. ALTERNATIVE APPROACHES/OPTIONS

Continue at current pace and accept limited capability, especially in advanced spacecraft S/W systems.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

None related to spacecraft application. One small RTOP at JSC related to ground application (Advanced Dev 910 RTOP).

9. TECHNOLOGY SCHEDULES

	FY																			
SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
B. Gen. Purpose Grd. S/W Res. & Anal																				
A. Techn. Inven.																				
Techn. Reqmts.																				
Math comp																				
S/C Appl Anal																				
Gnd Appl Anal																				
H/W Compat																				
Documentation																				

Representative Cycle for
Mission-oriented Algorithm
Development. Cycles could
repeat for 10-15 years.

MANPOWER (M-Y)																				
INHOUSE			3.5	4	4	4	3													
CONTRACT			6	7	7	6	5													
FUNDING (10 ⁶ \$)																				
INHOUSE			.13	.15	.17	.17	.13													
CONTRACT			.4	.5	.5	.5	.4													

Per application cycle
General purpose

.23	.30	.35	.30	.18
.3	.3	.3	.3	.3

Total 1.3 M per cycle
Continuous level 0.3 M/year

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Programming Languages and TranslatorsNO. 10-11-12-1/E-4/14
THEME / W.G. / TASKDATE 4 / 28 / 76

2. OBJECTIVE

Develop effective, reliable languages for expressing program specifications, design and implementation, plus efficient translators.

3. NEED ANALYSIS

a) LEVEL NOW ☒ 4, WILL BE LEVEL ☒ 4 UNDER EXISTING PLANS.b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1981

c) RISK IN ACHIEVING ADVANCEMENT:

HIGH ☐ MEDIUM ☐ LOW ☒d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR
ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐OTHER (Specify) ☐ (Check one or more)f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR

USE OF THIS TECHNOLOGY Language theory development for related area5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO
ACCOMPLISH NEEDRequirements analysis and specification languagesDesign languagesProgramming languagesData and control abstractionsIntermediate languagesCode optimizationTranslator writing systemsCorrectness proof systems5. COMPONENT OR BREADBOARD TESTED IN RELEVANT
ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENTLEVEL
OF STATE
OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR
MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE PROGRAMMING LANGUAGES AND TRANSLATORS

NO. 10-11-12-1/E-4/14

THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Identify language areas and needs.

Develop requirements/specifications formalisms.

Define base design language consistent with modern programming methodologies.

Develop implementation languages together with efficient, portable compiler writing systems.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

FY

SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Lang. Areas																				
Reqs/Specs																				
Design Lang.																				
Impl. Langs.																				

MANPOWER (M-Y)

INHOUSE

CONTRACT

FUNDING (10⁶ \$)

INHOUSE

CONTRACT

4 4 4 4

8 10 4 4

.2 .2 .2 .2

.5 .6 .3 .3

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

LEVEL
OF STATE
OF ART

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 1 OF 2

1. TITLE Software Verification/Validation

NO. 10-12-8-7-11-1/E-4 15

Techniques

THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

To develop methodologies/automated tools to accomplish software verification/validation in less time and at a reduced cost

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 3, WILL BE LEVEL ☐ 4 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☐ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1982
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☒ LOW ☐
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐
- e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☐ (Check one or more)
- f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

Programming languages and translators

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Provide automated and interactive tools for increasing confidence level of software during the verification/validation stages of software development such as static and dynamic testing tools.

Methodology to insure traceability of software requirements through all stages of development such as requirements/specification format language(s).

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Efficient Emulation NO. 12-11-10-1/E-4/16
THEME / W.G. / TASK
DATE 4 / 28 / 76

2. OBJECTIVE

Determine, provide and apply, efficient emulation technology for flight software development and for portability of ground software.

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 4, WILL BE LEVEL ☒ 4 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1984
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☒ LOW ☐
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐
- e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☐ (Check one or more)
- f) R&T BASE CANDIDATE YES

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Use a variable architecture computer to efficiently provide rapid access to several computing environments within a single machine. Develop methods of using this capability to provide:

1. A convenient, powerful development and testing environment for flight software.
2. More efficient execution of specific languages or applications.
3. Increased portability of software from other installations.
4. Capability for performing software-first designs.

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE EFFICIENT EMULATION

NO. 12-11-10-1/E-4/16
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Study available techniques for variable-architecture machine s/w development.

Develop methods of using variable-architecture capability for _____

- Increased portability of software from other installations.
- Environment for developing flight software.
- More efficient execution of specific languages/applications.
- Software-first design of data-processing functions/systems.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

DOD & University research with variable-architecture machines.

9. TECHNOLOGY SCHEDULES

FY

[illegible][illegible]

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Software Simulation Technology

NO. 12-10-11-1/E-4/17
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

Develop S/W technology to provide improved simulation software techniques

3. NEED ANALYSIS

a) LEVEL NOW ☒ 2, WILL BE LEVEL ☒ 2 UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1983

c) RISK IN ACHIEVING ADVANCEMENT:

HIGH ☐ MEDIUM ☒ LOW ☐

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐

e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☒

OTHER (Specify) ☐ (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Software technology (Architecture, languages, automation, interface, etc.) is required to aid the following simulation functional areas;

(1) the determination of the simulated system functions, (2) conversion of simulated system functions into S/W formulation requirements and S/W specs., (3) correction of simulation S/W-code, architecture, etc., (4) checkout of simulation software.

TITLE SIMULATION SOFTWARE TECHNOLOGY

NO. 12-10-11-1/E-4/17

THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Develop and/or improve s/w technology to minimize the human element used in providing simulation s/w. This is accomplished by 1) surveying existing technology, 2) determining technology limits, 3) developing new concepts to base new technology on, 4) development of tools required to support new technology development, 5) implement, test, and modify new concepts and technology.

7. ALTERNATIVE APPROACHES/OPTIONS Live with general industry advances
in the simulation area

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

There are activities in this area, but not as extensive or specific as the objectives given in parts 2 and 5.

9. TECHNOLOGY SCHEDULES

[illegible][illegible]

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

LEVEL
OF STATE
OF ART

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Programming Methodology

NO. 10-11-12-9-1/E-4/18
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

Reduce software development and life cycle costs with a coordinated
system of human work methods and computer support tools based on modern
programming principles

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 2, WILL BE LEVEL ☒ 3 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY
AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1983
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☒ LOW ☐
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR
ENHANCING: HIGH ☒ MEDIUM ☐ LOW ☐
- e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☐ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☐ (Check one or more)
- f) R&T BASE CANDIDATE YES 5M (506-20-15 100K)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Develop and integrate a system of human work methods and supporting
computer tools that will focus the human effort in software development
and management on the uniquely human functions of creative problem solving
and evaluation of design choices. Base the system on modern programming
techniques such as structured programming, specification and program design
languages, abstract data representations, etc., and on the common princi-
ples underlying them. Make the system easily usable for both journeyman
and expert software developers. Use pilot applications to prove out and
demonstrate the system, and to provide the basis for educating users.
Provide methods for evaluation of program cost elements.

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

LEVEL
OF STATE
OF ART

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 1 OF 2

1. TITLE Software Commonality

NO. 11-10-12-9-1/E-4/19
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

To develop improved technology for shareable software

3. NEED ANALYSIS

- a) LEVEL NOW ☒ 2, WILL BE LEVEL ☒ 4 UNDER EXISTING PLANS.
- b) REQUIRED ADVANCEMENT - SHOULD BE TECHNOLOGY READY AT LEVEL ☒ 5 FOR OPERATIONAL SYSTEM USE BY DATE: 1982
- c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☐ LOW ☒
- d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☐ OR ENHANCING: HIGH ☒ MEDIUM ☒ LOW ☐
- e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☒ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☐ (Check one or more)
- f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

Programming language standardization

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Provide means by which software can be implemented and shared between computer systems for performing common functions.

Design portability.

High order language standardization.

Common software library generation/access techniques.

Documentation/distribution/configuration control of common software library programs.

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE SOFTWARE COMMONALITY

NO. 11-10-12-9-1/E-4/19
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

- 1) Implement HOL standardization procedures within NASA and in coordination with other agencies.
- 2) Develop software portability and concepts and create the structure for their implementation.
- 3) Implement common software library program, define procedures, and initiate library.

7. **ALTERNATIVE APPROACHES/OPTIONS** No options for development of concepts, implementation trades between in-house, contractor, tasks.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

FY

[illegible][illegible]

SPACE TECHNOLOGY NEED PRIORITY ASSESSMENT											FORM II FORM III
(List in numerical order, 1 - Highest Priority)											WORKING GROUP E-4
DATE 4 / 28 / 76											
THEME NO. TECHNOLOGY NEED NO.	7 SPACE POWER	8 SPACE INDUST.	9 SETI	10 SOLAR SYS. EXPL.	11 GLOBAL SERVICE	12 ADV. TRANS. SYS.	NASA R&T		SUMMARY PRIORITY ASSESSMENT		
							Current	R&T Base	WG	TT	OAST DIV.
1. Multidimensional Data Systems	2	2	5	6	1			2	2		
2. High Volume Data Buffering			2	9	8				12		
3. Teleoperator Support SW	3	3			12	10			10		
4. Mission Planning & Scheduling Tools	1	1		3	10	1			1		
5. Autonomous Systems With Artificial Intel	4	4	4	1	19	11			5		
6. Pattern Recognition			1	5	4			12	3		
7. Automated Programming				17	18	7		14	19		
8. System Security Software	5				11				13		
9. Software for Sys. Integrity	6	5	7	10	3	2		3	4		
10. Evolutionary Software	9	8	3	16	7	13		7	8		
11. Operations Languages	7	6		11	2	6		4	7		
12. Intelligent Exec. Programs			6	14	6	3		11	11		
13. Algorithms/ Numerical Anal.			10	4	5	8			9		

